

Dryden Flight Research Center Overview



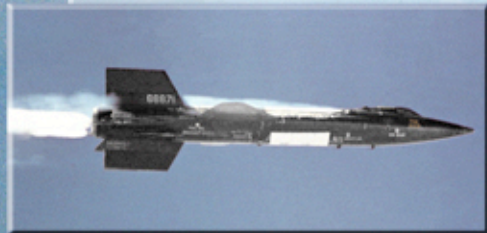
An aerial photograph of the Edwards Air Force Base and the NASA Dryden Flight Research Center. The base is located in a desert environment with a large, flat, light-colored area in the foreground. The base itself is a complex of various buildings, runways, and taxiways. A red circle highlights a specific area within the base, which is identified as the NASA Dryden Flight Research Center. The background shows a range of mountains under a clear sky.

Edwards Air Force Base

- Dedicated Airspace
- 350 Flyable Days Per Year
- 15,000 Ft Concrete Runway
- Lakebed Runways
- Supersonic Corridor

**NASA Dryden Flight
Research Center**

To Fly What Others Only Imagine



Dryden's Mission:

Advancing Technology and Science Through Flight



✓ **Mission Elements:**

- ✓ **Perform** flight research and technology integration to revolutionize aviation and pioneer aerospace technology,
- ✓ **Validate** space exploration concepts,
- ✓ **Conduct** airborne remote sensing and science observations,
- ✓ **Support** operations of the Space Shuttle and the ISS

... for NASA and the Nation.

Flight Research



**Support
Space Exploration Concepts**



Science Observations



STS Operations





NASA Dryden Flight Research Center - Statistics



FY07 Statistics:

Civil Servant Staff 530

On-site Contractors ~500

Budget ~\$220M



Examples of Recent Flight Research Projects



Autonomous Aerial Refueling

- ✓ Utilized piloted F-18 as a test bed for autonomous aerial refueling
 - ✓ Simulated unoccupied aircraft with a safety pilot
 - ✓ Allows quicker demonstration of technology



“Quiet Spike” Demonstration on Supersonic F-15



- ✓ Extending noseboom or spike, “Quiet Spike”, for sonic boom reduction
 - ✓ Extendable nose boom
 - ✓ Extends for supersonic flight
 - ✓ Retracts for landing





Intelligent Flight Controls

- ✓ Adaptive flight controls research utilizing Neural Nets
 - ✓ Adapts flight control laws real time with neural nets
 - ✓ Damage or system failure accommodation





Current Flight Research and Science Projects

High Angle of Attack research on Blended Wing Body Configuration



- ✓ 10% Scale model of Blended Wing Body, X-48, investigates high angle of attack and departure susceptibility of configuration



Predator B Unmanned Aerial Vehicle Supports Firefighters in Western States



- ✓ Predator B aircraft carries Infrared sensor to visualize fires through smoke
 - ✓ Provides real time data to firefighters
 - ✓ Used in recent (October) Southern California fires





Orion Launch Abort Tests

- ✓ NASA Dryden leads Orion launch abort tests



NASA Variant of U-2, ER-2, used for Earth Science



•Recent and Upcoming Science Missions on ER-2

- ✓ Tropical Cloud, Composition and Climate Coupling (Costa Rica – August 2007)
 - ✓ Tropospheric research in the tropical Eastern Pacific
 - ✓ Satellite validation and process studies
- ✓ Cloud and Land Surface Interaction Campaign (Oklahoma – May 2007)
 - ✓ High resolution measurement of 3-dimensional cloud field boundaries
 - ✓ Cloud land process interactions
- ✓ Capabilities:
 - ✓ Very high altitude (above 70,000 ft), long range (over 7,000 nautical miles)
 - ✓ 2,900 lbs payload, in-situ and remote sensing



DC-8 Airborne Platform for Earth Science



Recent and Upcoming DC-8 Science Missions

- ✓ North American Monsoon (Cape Verdi – August 2006)
 - ✓ Cyclo-genesis research
- ✓ Arctic Research on the Composition of the Troposphere using Aircraft and Satellites (Alaska – April 2008)
 - ✓ Polar tropospheric research and satellite validation
- ✓ Capabilities:
 - ✓ Inter-continental transects, altitudes from 500 ft to 42, 000 ft
 - ✓ Shirt-sleeve environment for up to 23 experiment teams
 - ✓ 30,000 lbs payload, in-situ and remote sensing



Stratospheric Observatory for Infrared Astronomy, (SOFIA)

Overview



Bob Meyer
SOFIA Program Manager



Background

- ✓ SOFIA established as a 80/20 partnership between NASA and DLR
 - ✓ Original NASA/DLR MOU signed 1996
 - ✓ Germany supplied telescope assembly and other significant contributions
 - ✓ NASA supplied modified aircraft and Science Operations Center
 - ✓ NASA receives 80% of available science time, DLR 20%
- ✓ Heavily modified Boeing 747 SP
- ✓ Airborne Astronomy Observatory
 - ✓ 2.5 M Telescope mounted in aft fuselage
- ✓ Aircraft modification accomplished at L3 in Waco, Tx
- ✓ Aircraft currently undergoing flight test at NASA Dryden



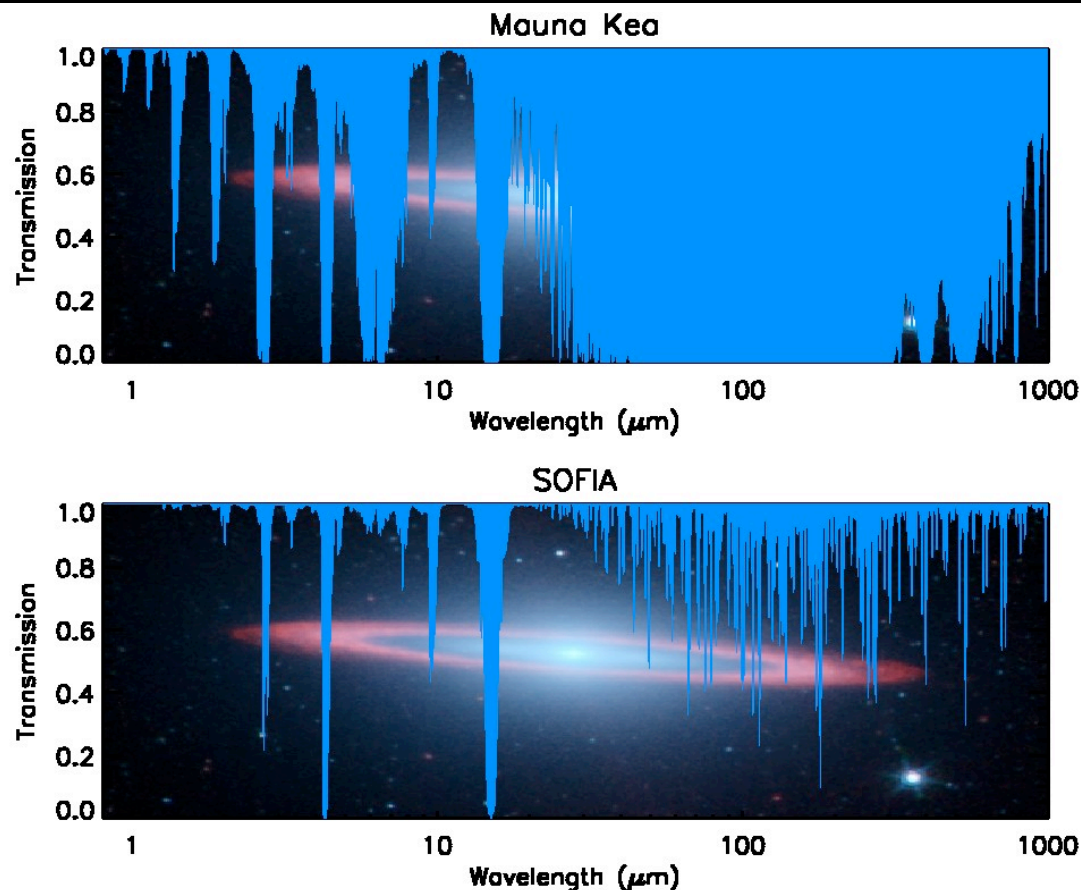
Program Level Requirements

- ✓ Telescope Requirements
 - ✓ Effective aperture of telescope: 2.5 meters
 - ✓ Telescope elevation range (unvignetted): 20 – 60 degrees
 - ✓ Telescope wavelength range: 0.3 to 1600 microns
 - ✓ Telescope image size: 80 percent of encircled energy
 - ✓ 5.3 arcsecond diameter at the focal plane at First Science Flight
 - ✓ Goal 1.6 arcseconds diameter at FOC*
- ✓ Operational capability: 6 Hours above 41,000 ft
- ✓ At Least 40 Principal or Guest Investigator teams per year at FOC
- ✓ 960 science hours
- ✓ Global Operations
- ✓ Twenty year operational life
- ✓ Promote educational opportunities and public outreach

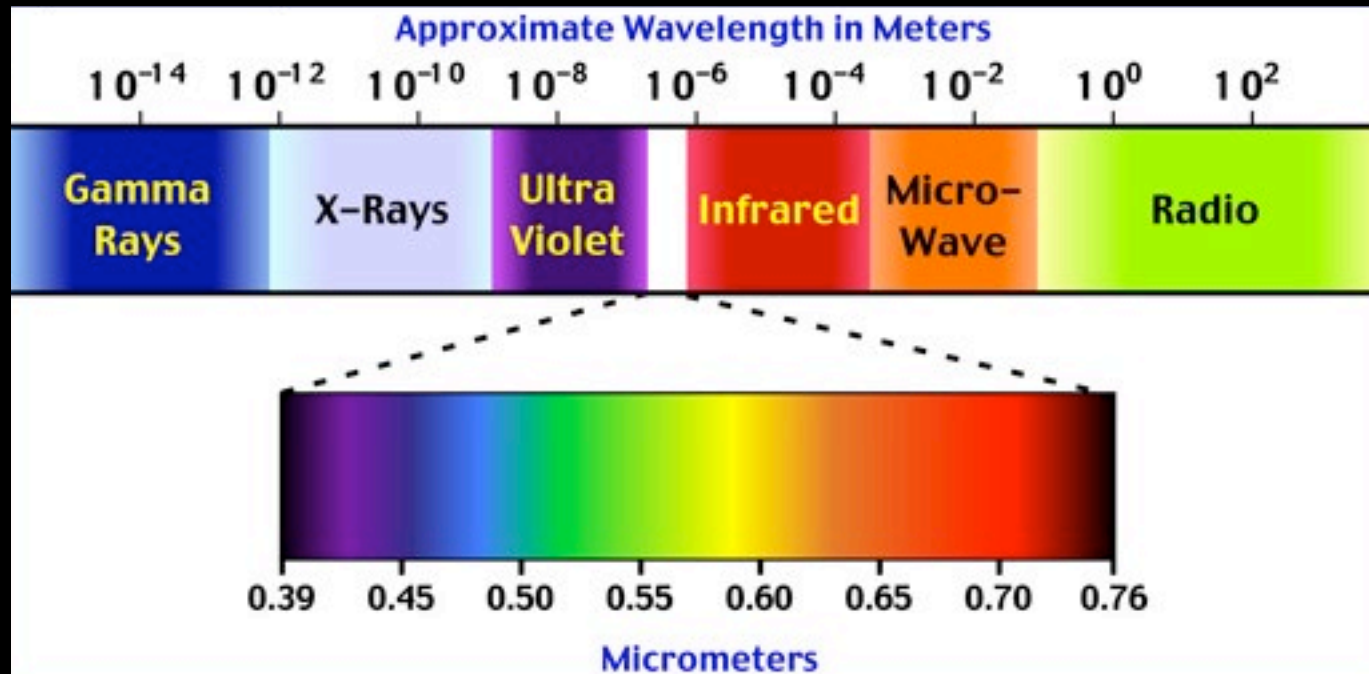


Why SOFIA?

- ✓ Infrared is filtered by moisture in atmosphere
- ✓ At 41,000 ft, above 99% of the water vapor
- ✓ Gather very important science data
 - ✓ Further understanding of star and solar system formation
 - ✓ Look for evidence of complex biogenic molecules (origins of life!)
- ✓ Mobility: anywhere, anytime
- ✓ Long lifetime
- ✓ A near-space observatory that comes home after every flight



The physics of light ...



Infrared is just above the visual range

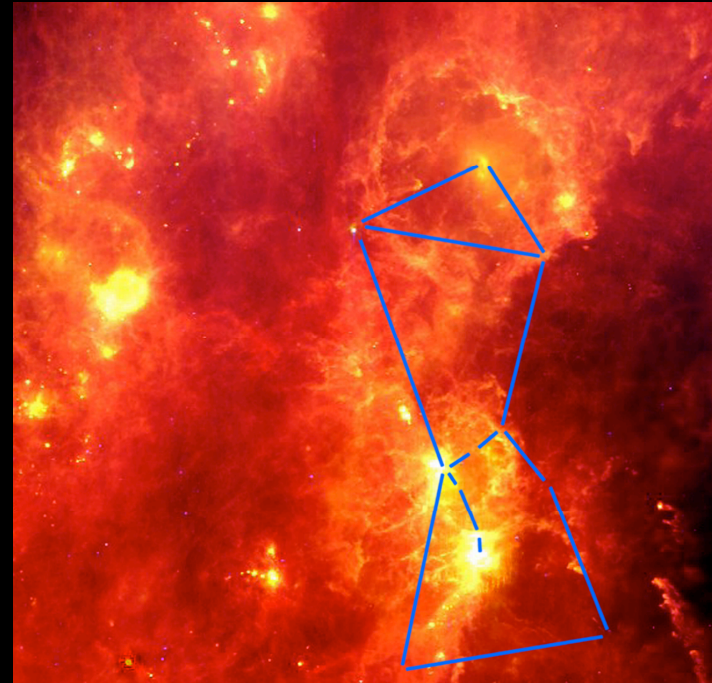
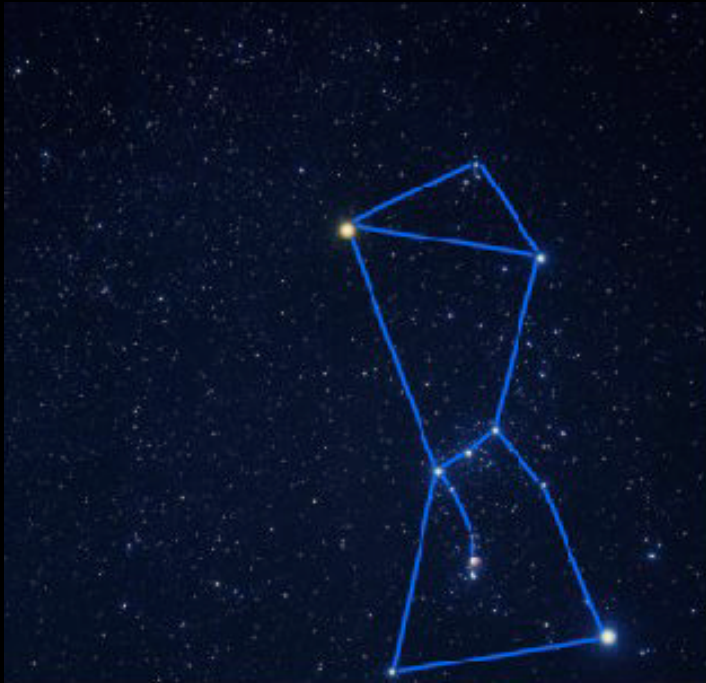
William Herschel



Discovery of Infrared Radiation - 1800

Getting the WHOLE picture

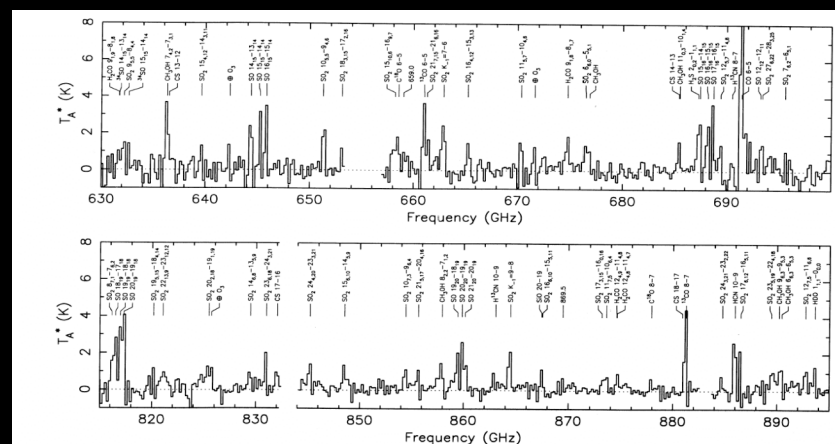
- An object can look radically different depending on the type of light collected from it:



Constellation Orion
left: visual wavelengths
right: far-infrared image

- Most molecular lines in IR or submillimeter
- Need high spectral resolution throughout IR and submillimeter
- As sensitive as CSO, but complete wavelength range is accessible (ie. H_2 , C_2H_2 , CH_4 only in IR)
- Light molecules: Hydrogen, water, other hydrides in IR and submillimeter
- HD at 112 microns
- The fullerene, C_{60} , has 4 IR lines in SOFIA's bands

CSO FTS Spectrum of ORION OMC1

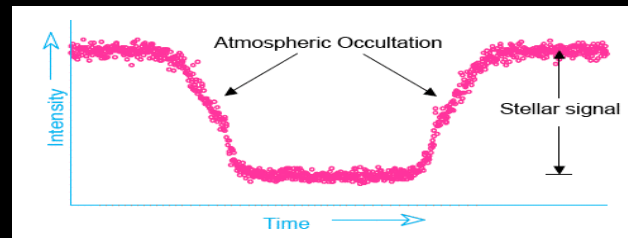


Serabyn and Weisstein 1995

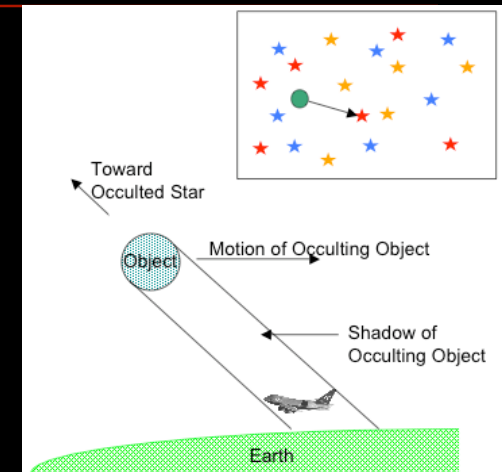
Occultation Astronomy with SOFIA



SOFIA will measure stellar occultations



Pluto occultation lightcurve observed on the KAO (1988) probes the atmosphere

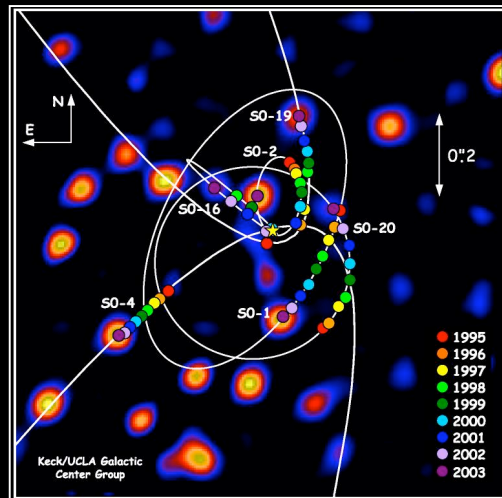


- SOFIA can fly anywhere on the Earth, allowing it to position itself under the shadow of an occulting object
- Occultation studies with SOFIA will probe the sizes, atmospheres, and possible satellites of Kuiper belt objects and newly discovered planet-like objects in the outer Solar system. The unique mobility of SOFIA opens up some hundred events per year for study compared to a handful for a fixed observatory.
- SOFIA's mobility also enables study of comets, supernovae and other serendipitous objects

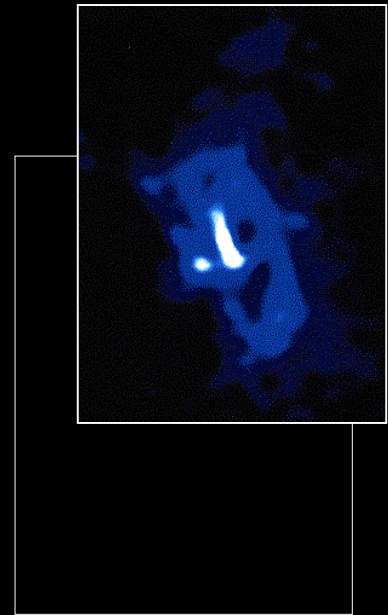
Feeding the Black Hole in the Center of the Galaxy



One of the major discoveries of the KAO was a ring of dust and gas orbiting the very center of the Galaxy



Astronomers at ESO and Keck detected fast moving stars revealing a 4×10^6 solar mass black hole at the Galactic Center

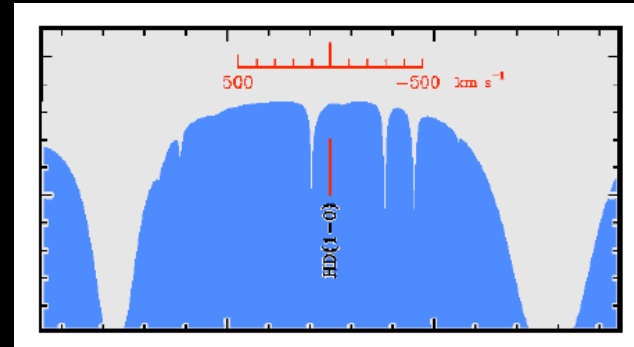


- ✓ The ring of dust and gas will fall into the black hole
- ✓ SOFIA's angular resolution and spectrometers will tell us:
 - ✓ How much matter gets fed into the black hole?
 - ✓ How much energy is released?
 - ✓ What is the relationship to high energy active galactic nuclei?



Evolution of the Universe

SOFIA will study the deuterium abundance in the galaxy, investigating the evolution of the universe



Atmospheric transmission around the HD line at 40,000 feet

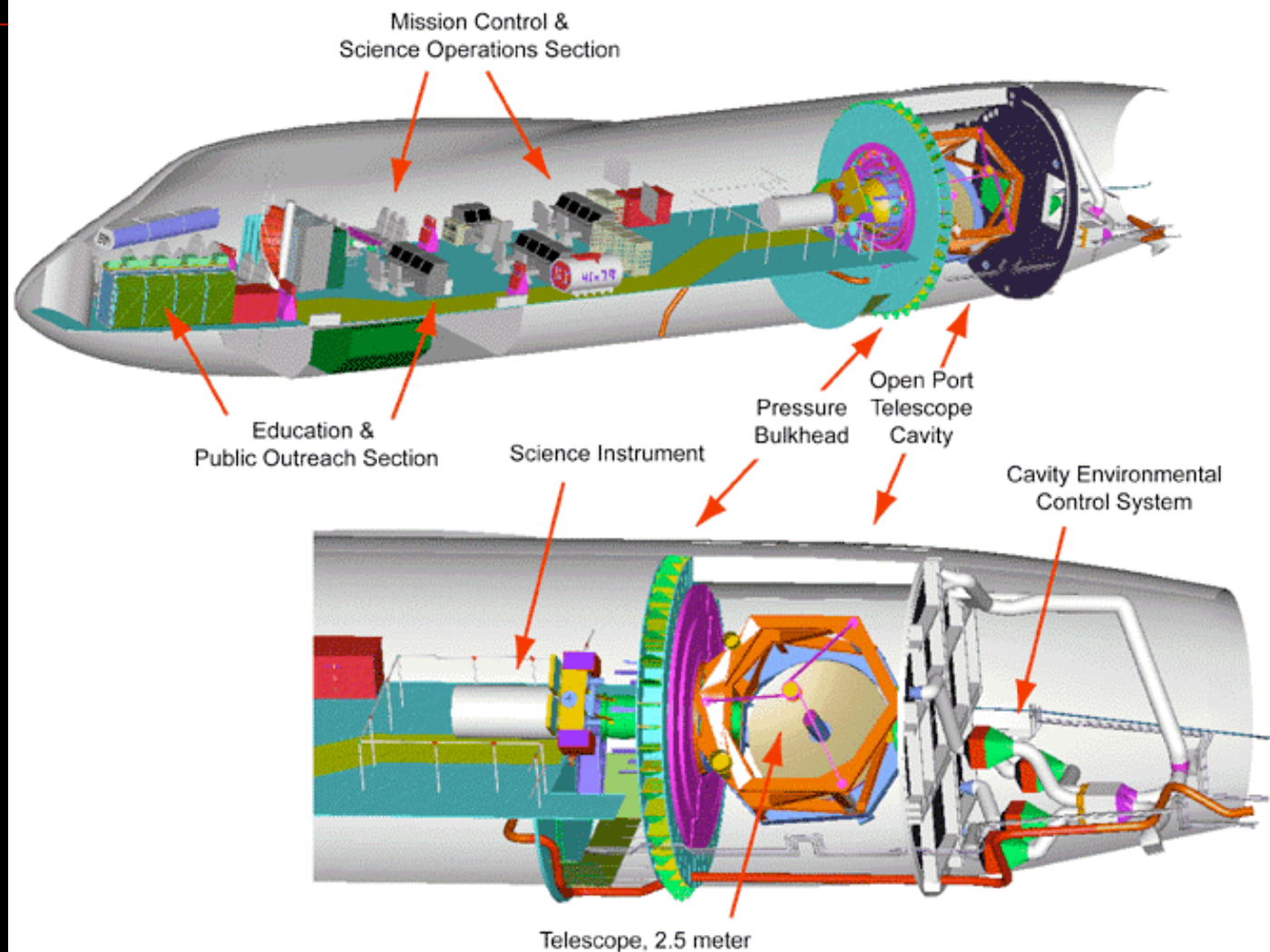
Deuterium in the universe is created in the Big Bang and the primordial deuterium abundance provides the best constraints on the mass density of baryons in the universe. However, this Big Bang record is subsequently modified by stellar nuclear burning as material cycles from stars to the interstellar medium and back to stars.

Only the high resolution spectrograph on SOFIA can measure the deuterium abundance throughout our galaxy and answer:

- What is the abundance of deuterium and how does it vary with the local star formation rate in galaxies?
- What does that tell us about the Big Bang and about the star formation history of galaxies?
- As pointed out by Bergin, Hollenbach and others, HD can also give the Molecular Hydrogen abundance.

Layout of Personnel and Accommodations

(upper deck not shown)

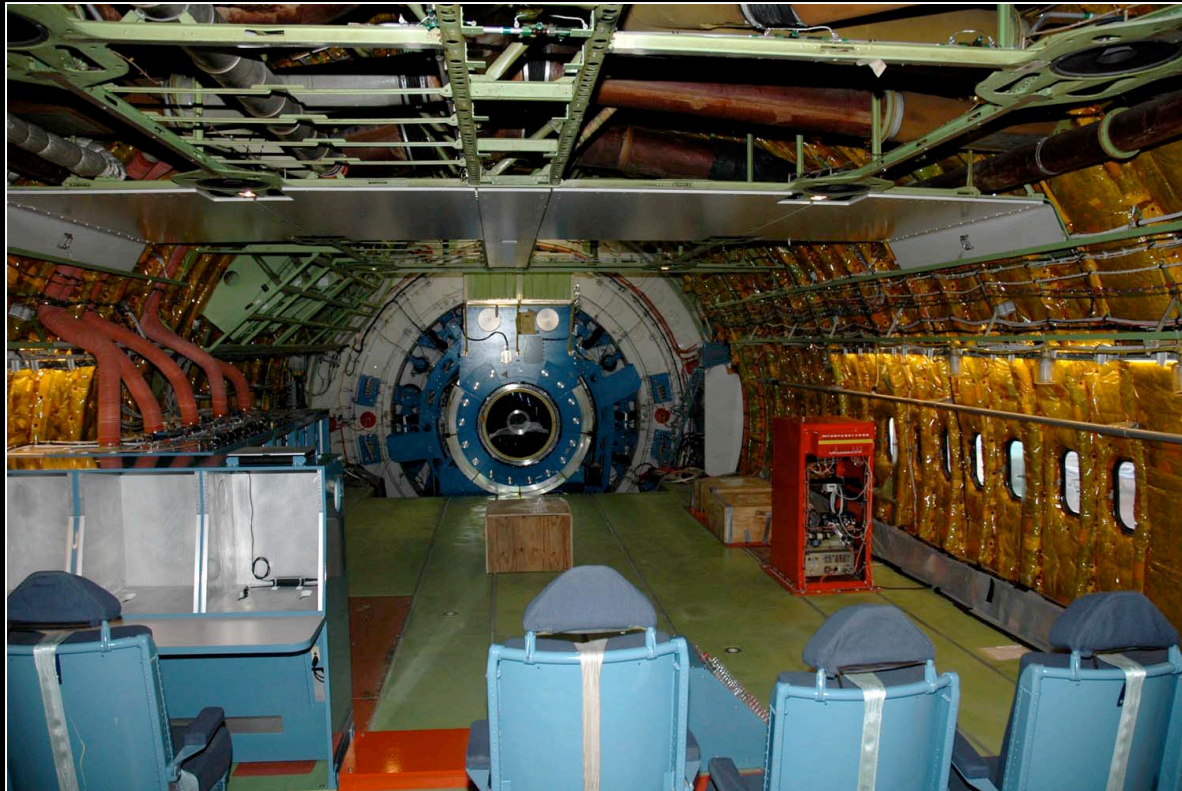




Telescope Cavity, with Doors open



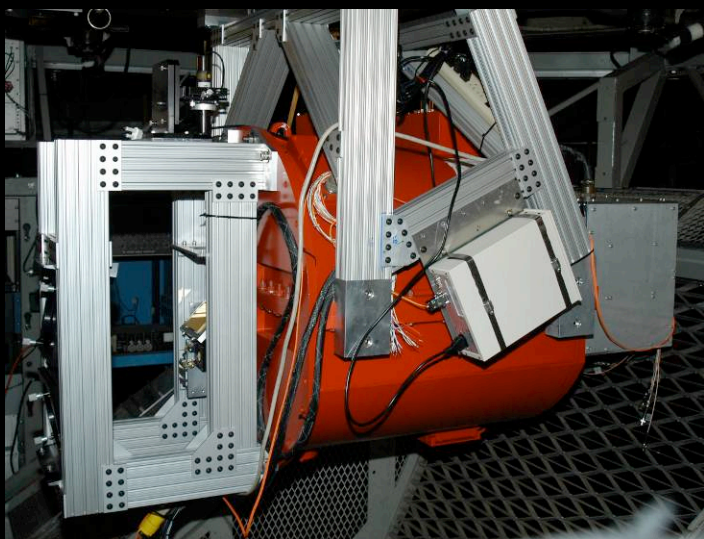
Cabin Area Looking Aft at Telescope



FORCAST



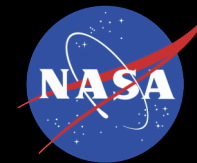
SI: A Wide-field Infrared Camera for SOFIA
PI: Terry Herter
Institution: Cornell University
Class: US facility science instrument
Type: Large field-of-view, narrow- and broad-band photometric imaging and moderate-resolution spectroscopy from 4 to 42 μm
Test: Secondary SOFIA test instrument
Science: Multicolor imaging of the Galactic Center, vega-like dust clouds, & star formation in normal and active galaxies, including our own



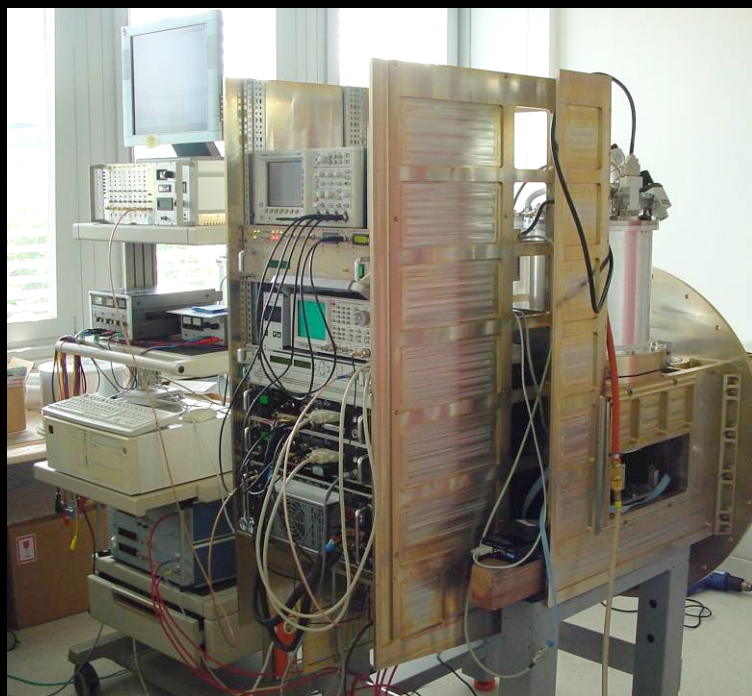
Status: Two test runs at Palomar; hardware nearly complete; some documentation & airworthiness activities remain for use on SOFIA

Spent thru 2006:	\$6.0M
Current year budget:	\$0.9M
Cost to Complete:	\$2.8M
Total Cost:	\$9.6M

GREAT



SI: German Receiver for Astronomy at THz Frequencies
PI: Rolf Güsten
Institution: Max-Planck-Institut für Radioastronomie, Bonn
Class: German principal-investigator science instrument
Type: Dual-channel heterodyne instrument for high-resolution spectroscopy in bands centered at 64, 120, and 170 μm
Test: Instrument commissioning only



Science: Abundance of deuterium, energetics of the interstellar medium, kinematics of the Galactic center

Status: End-to-end test of one band; integrated system testing in progress, some documentation, software, & airworthiness activities remain

No US funds expended

FIFI-LS



SI: Field-Imaging Far-Infrared Line Spectrometer

PI: Albrecht Poglitsch

Institution: Max-Planck-Institut für extraterrestrische Physik, Garching

Class: German principle-investigator science instrument

Type: 3D integral field far-infrared spectrometer with simultaneous observing in two channels (42 – 110 and 110 – 210 μm)

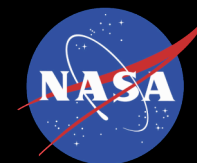
Test: Instrument commissioning only

Science: Triggered star formation, relationship between active galactic nuclei & starbursts; morphology of heating & cooling in galaxies

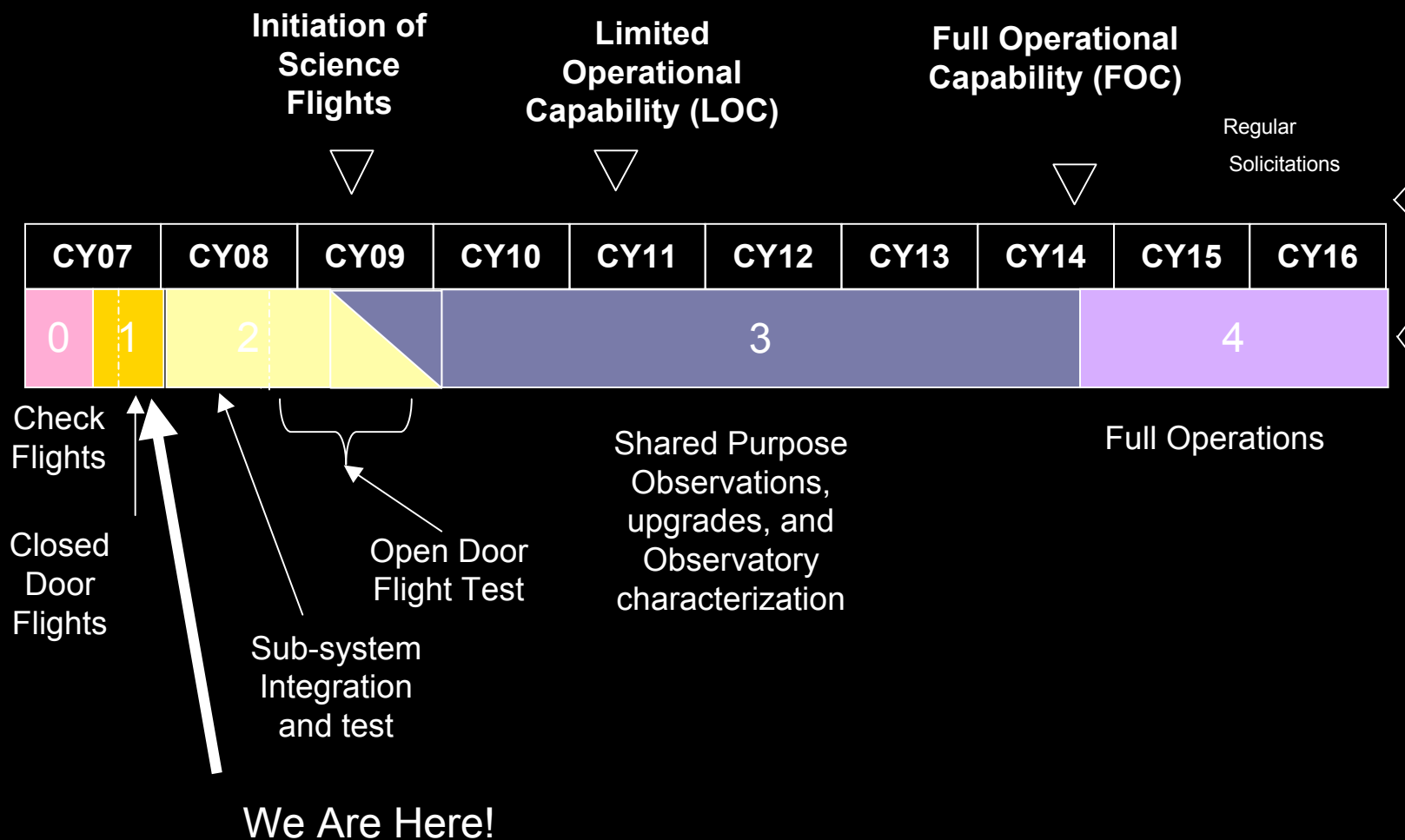


Status: Cryostat and optics integrated and tested; red detector operational; instrument integration, including blue detector, electronics, documentation, software, & airworthiness in progress

No US funds expended, but plans to fund Extended Observing Opportunity Program to develop and support an FSI-like mode for use by US guest investigators



SOFIA Flight Segments





Video



Summary

- ✓ NASA Dryden is an exciting Center!
 - ✓ Cutting edge aeronautics work
 - ✓ Leading edge Science activities
- ✓ SOFIA presents opportunity for German scientists and students
 - ✓ Participate in observatory development
 - ✓ Lead astronomical observations
- ✓ Hope to see some of you at NASA Dryden!